CLAIMS

1. A receiver, for use in an OFDM type transmission system, in which data is transmitted in frames, each frame having a cyclic prefix which is a repetition of part of said frame, characterised in that control means are provided which control a sampling oscillator, and in that said control means include estimation means for estimating timing deviations of said sampling clock, said estimation means operating entirely on frequency domain input data.

2. A receiver, for use in an OFDM type transmission system, in which data is transmitted in frames, each frame having a cyclic prefix which is a repetition of part of said frame, and in which said receiver has an adaptive equaliser having an equaliser inverse channel model, characterised in that separation means are provided for separating said equaliser inverse channel model into a first and a second part, said first part being independent of sample timing and said second part being dependent on sample timing and in that control means are provided which control a sampling oscillator in dependence on said second part.

3. A receiver, as claimed in claim 2, characterised in that said control means include estimation means for estimating timing deviations of said sampling clock, said estimation means operating entirely on frequency domain input data.

4. A receiver, as claimed in claim 3, characterised in that said estimation means estimate an approximation of a linear portion of an argument function produced by timing deviations of said sampling oscillator.

5. A receiver, as claimed in claim 4, characterised in that said estimation means is adapted to find a linear part of said argument function by taking an average slope of said argument function.

6. A receiver, as claimed in either claim 4, or claim 5, characterised in that said approximation of a linear portion of an argument function is used as a feedback control signal for said sampling clock.

7. A receiver, as claimed in claim 6, characterised in that said approximation of a linear portion of an argument function has a slope which converges to zero as a control loop, for said sampling clock, settles.

8. A receiver, as claimed in claim 7, characterised in that those parts of said equaliser inverse channel model, other than said linear portion of said argument function, are controlled by said equaliser, which continuously adapts to variations in sampling timing.

9. A receiver, as claimed in claim 8, characterised in that said equaliser and said control means each use well defined and different portions of said equaliser inverse channel model to achieve an output frequency domain signal with zero phase deviation relative to a transmitted signal.

10. A receiver, as claimed in any ~~of~~ claims 7 to 9, characterised in that said slope of said argument function, α_k, is estimated from the equation

$$\alpha_k = \frac{1}{N} \sum_n \angle \frac{X_{n,k}}{n}$$

where N is the number of active carriers and $X_{n,k}$ is the unwrapped argument function for the nth active carrier in the kth frame.

11. A receiver, as claimed in any of claims 7 to 9, characterised in that said slope of said argument function, α_k, is estimated from the equation

$$\alpha_k = \frac{2}{n_2 - n_0} \left[\sum_{n=n_1+1}^{n_2} \angle X_{n,k} - \sum_{n=n_0}^{n_1} \angle X_{n,k} \right]$$

where N is the number of active carriers, $X_{n,k}$ is the unwrapped argument function for the nth active carrier in the kth frame, indices n_0 and n_2 are the lower and upper limits respectively of the band and index n_1 divides the band into two equal parts.

12. A receiver, as claimed in any previous claim, characterised in that, on start up, frame timing is adjusted until received frames are sampled inside a signal interval.

13. A receiver, as claimed in claim 12, characterised in that means are provided, responsive to a feed back control for said sampling oscillator, to adjust said frame timing so that frame synchronization is maintained.

14. An OFDM type transmission system in which data is transmitted in frames, each frame having a cyclic prefix which is a repetition of part of said frame, characterised in that said system includes a receiver as claimed in any of claims 1 to 13 .

15. In an OFDM type system in which data is transmitted in frames, each frame having a cyclic prefix which is a repetition of part of said frame, a method of synchronising a receiver sampling oscillator with a transmitter sampling oscillator, characterised by controlling said sampling oscillator with a feedback signal representing an estimation of timing deviations of said sampling clock, said estimation signal derived directly from domain input data.

16. In an OFDM type system in which data is transmitted in frames, each frame having a cyclic prefix which is a repetition of part of said frame, and in which said receiver has an adaptive equaliser having an equaliser inverse channel model, a method of synchronising a receiver sampling oscillator with a transmitter sampling oscillator, characterised by separating said equaliser inverse channel model into a first and a second part, said first part being independent of sample timing and said second part being dependent on sample timing and controlling a sampling oscillator in dependence on said second part.

17. A method, as claimed in claim 16, characterised by estimating timing deviations of said sampling clock entirely from frequency domain input data.

18. A method, as claimed in claim 17, characterised by estimating an approximation of a linear portion of an argument function produced by timing

deviations of said sampling oscillator.

19. A method, as claimed in claim 18, characterised by finding a linear part of said argument function by taking an average slope of said argument function.

20. A method, as claimed in either claim 18, or claim 19, characterised by using said approximation of a linear portion of an argument function as a feedback control signal for said sampling clock.

21. A method, as claimed in claim 20, characterised by said approximation of a linear portion of an argument function having a slope which converges to zero as a control loop, for said sampling clock, settles.

22. A method, as claimed in claim 21, characterised by controlling those parts of said equaliser inverse channel model, other than said linear portion of said argument function, with said equaliser, which continuously adapts to variations in sampling timing.

23. A method, as claimed in claim 22, characterised by said equaliser and said control means each using well defined and different portions of said equaliser inverse channel model to achieve an output frequency domain signal with zero phase deviation relative to a transmitted signal.

24. A method, as claimed in any of claims 21 to 23 , characterised by estimating said slope of said argument function, α_k, from the equation

$$\alpha_k = \frac{1}{N}\sum_n \angle \frac{X_{n,k}}{n}$$

where N is the number of active carriers and $X_{n,k}$ is the unwrapped argument function for the nth active carrier in the kth frame.

25. A method, as claimed in any of claims 21 to 23, characterised by estimating said slope of said argument function, α_k, from the equation

$$\alpha_k = \frac{2}{n_2 - n_0}\left[\sum_{n=n_1+1}^{n_2} \angle X_{n,k} - \sum_{n=n_0}^{n_1} \angle X_{n,k}\right]$$

where N is the number of active carriers, $X_{n,k}$ is the unwrapped argument function for the nth active carrier in the kth frame, indices n_0 and n_2 are the lower and upper limits respectively of the band and index n_1 divides the band into two equal parts.

26. A method, as claimed in any of claims 15 to 25, characterised by adjusting frame timing, on start, until received frames are sampled inside a signal interval.

27. A method, as claimed in claim 26, characterised by adjusting said frame timing in accordance with a feed back signal for said sampling oscillator, so that frame synchronization is maintained.

28. An ADSL modem characterised in that said modem has a receiver as claimed in any of claims 1 to 13, or operates a method of synchronisation as claimed in any of claims 15 to 27

29. A VDSL modem characterised in that said modem has a receiver as claimed in any of claims 1 to 13, or operates a method of synchronisation as claimed in any of claims 15 to 27.

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